AT MICROFICHE REFERENCE LIBRARY
A project of Volunteers in Asia

How to Make a Solar Still (Plastic Covered)
Do-it-Yourself Leaflet No. L-1

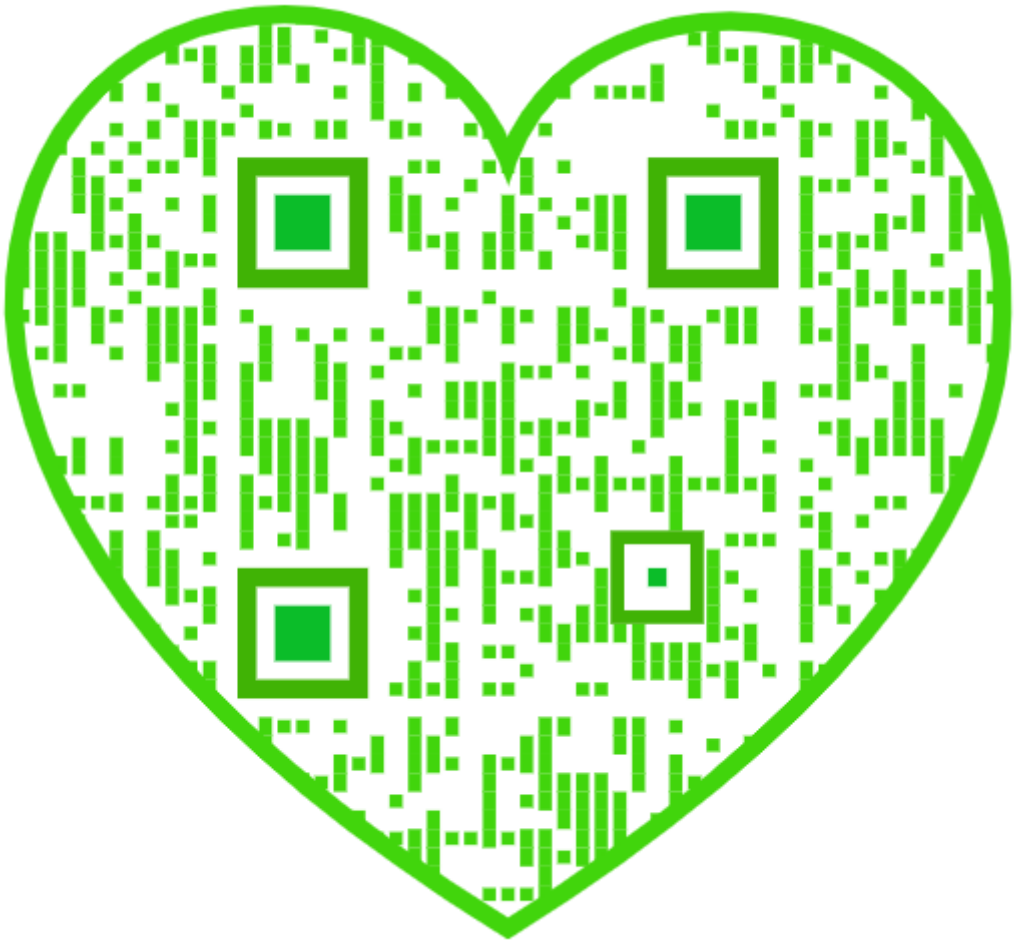
Published by:
Brace Research Institute
MacDonald College
McGill University
Ste. Anne de Bellevue 800
Quebec, Canada H9X 1C0

Paper copies are $ 1.25.

Available from:
Brace Research Institute
MacDonald College
McGill University
Ste. Anne de Bellevue 800
Quebec, Canada H9X 1C0

Reproduced by permission of Brace Research Institute, McGill University.

Reproduction of this microfiche document in any form is subject to the same restrictions as those of the original document.



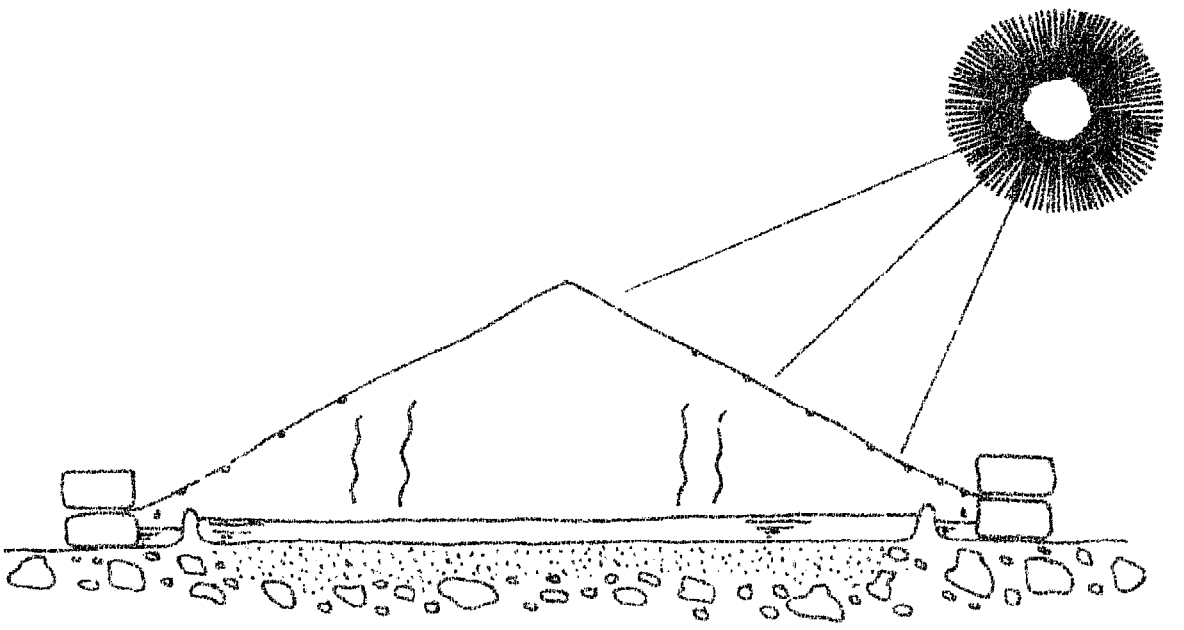
McGill University
Faculty of Engineering
BRACE RESEARCH INSTITUTE

How to Make A SOLAR STILL (Plastic Covered)

Do-it-Yourself Leaflet No. L - 1

January 1965

Revised February 1973



BRACE RESEARCH INSTITUTE
MacDONALD COLLEGE OF McGILL UNIVERSITY

STE. ANNE DE BELEVUE 800

QUEBEC, CANADA

HOW TO MAKE A SOLAR STILL (PLASTIC COVERED)

FOREWORD

A solar still is a simple device which can be used to convert saline, brackish,polluted or other water into drinking water. Its function is very simple--basically a pan of impure water is enclosed by a transparent cover. The latter traps solar energy within the enclosure. This heats up the water causing evaporation and condensation on the inner face of the sloping transparent cover. This distilled water is generally potable. This leaflet permits the user to make a relatively inexpensive unit, primarily out of plastic sheets and brick. It is not what might be recommended for a long-term installation. However, this plastic covered unit can certainly be adequately used for temporary installation. It should be stressed that the user should use as much flexibility and adaptation of local material as possible while not changing the general principles of the operation.

INTRODUCTION

The availability of modern engineering materials makes it possible to construct solar distillation equipment in large sizes at relatively low cost, and in any sunny area, where good drinking water costs more than about (U.S.)$5.00 per 1,000 gallons, solar distillation is certainly worth consideration.

The description given below represents one of many possible designs of solar distillation equipment. It has the advantage of being suitable for units producing anywhere from 1 gallon to 1,000 gallons per day, and will operate for long periods in isolated locations without attention. No auxiliary power source is needed, other than means for feeding water into the unit, and no site levelling is necessary.

AREA OF SOLAR STILL

In hot dry areas, each square foot of area in a solar still will produce between one half and three quarters pound distilled water daily, depending upon the time of year and amount of cloud cover, so that, generally speaking, about 12 sq. ft. of solar still area are needed to produce one gallon of water daily. Hence relatively large areas are needed to produce significant quantities of pure water.

DESCRIPTION OF SOLAR STILL (see Fig. 1)

Fig. 1 shows a cross-sectional view through a solar still that incorporates a black plastic water tray and a transparent plastic cover, galvanized steel guttering and concrete or brick side and end walls. The width is chosen to suit the width of the transparent plastic cover material, usually available in rolls 6 ft. wide. The length can be anything from a few feet to several hundred feet.

Orientation of the still is of no great importance, although obviously land sloping gently down towards the equator is best. The long dimension of the still is run down or across the natural slope of the land. The impure water is introduced in a slow steady stream at the high end and a small overflow at the low end carries away the remaining salts. Thus there is never any crystallization of salts in the unit. Small sand mounds beneath the bottom plastic liner create a series of impounding dams down the slope.

DEPTH OF WATER

The depth of water that is evaporated each day is about 1/8 inch, so nowhere should the water in the tray be less than about ¼ inch deep. The maximum desirable depth is 1 inch.

COLLECTION OF CONDENSED WATER

The condensed water droplets run down the underside of the transparent plastic cover into the side trough and then flow downhill to be stored in a suitable tank or reservoir. This tank can be a sealed plastic bag lying on the ground, with a suitable spiggot for drawing off the water when needed. The storage tank could also feed directly into animal drinking troughs with float control.

MATERIALS OF CONSTRUCTION

Most of the parts of the still are made from materials which are locally available in rural arid areas. Only a small number of parts, which are needed to give the still a good output and to prevent corrosion, must be imported into the area. These are both cheap and easy to transport. A materials list is given at the back of this leaflet.

The foundations are two strips of concrete 9 inches wide, 3 inches deep and 100 feet long. The bed of the salt water pond is simply levelled ground. The side and end walls do not need to be strong and can be made from local unburnt sun dried brick (adobe). Concrete block or pre-cast concrete sections may be cheaper for large installations. Wood should not be used because of possible termite attack, but the roof support props (Items 16, 17) may be made from wood as they stand in the water. The beds of the side gutters to collect the fresh water are made from galvanized steel sheets (Item 10). Other small items from galvanized steel are the two turnbuckles (7) for tightening the roof suspension cable, the six anchor posts (8) for holding the roof cable and the nails (9) for pinning the guttering to the concrete foundation.

The items which may have to be specially brought into the area are made from plastic. The first is the transparent cover material, which should be of plastic sheeting, 0.010 inch thick. (See Item 1, materials list) Two types which are suitable and relatively inexpensive are:

(1) ultra-violet resistant polyethylene sheet such as that developed for the greenhouse industry and fabricated by the principal chemical companies, e.g. Union Carbide, Canadian Industries Ltd., etc. Please bear in mind that this sheet will probably not last more than 6 months to 1 year in a very sunny region. The cost is of the order of $0.02 per square foot. Hence this unit will be suitable to cover installations that are only used seasonally, say 3 to 6 months of the year. It would be necessary to replace the cover every season.

(2) ultra-violet resistant transparent polyvinyl chloride sheet such as that made by B.F. Goodrich Co. This will probably last 2 to 4 years.

The plastic water tray and side liners (Items 2,3,4) should be made of 0.010 inch thick black polyethylene film. This is made by a number of different manufacturers in several countries. Polyethylene sheet is by no means the best liner material but it is inexpensive and in this regard it can be used for temporary installations of this nature. It would of course, be preferable for more permanent installations to use butyl rubber sheet such as that manufactured by the Miner Rubber Co. of Granby, Québec, Canada. The total cost of Items 2,3,4 is under U.S. $23. for each still. The salt water inlet and fresh water outlet pipes (Item 5) should be one half inch diameter heavy duty polyethylene hosepipe which is generally available and costs about $0.15 (U.S.) per foot. The plastic sheet roof is held up by a stretched steel wire (Item 6). Galvanized steel wire (1000 lb. breaking strength) may be used for cheapness but will have a short life due to corrosion. The best material is the stainless wire used by fishermen (1000 lb. breaking strength) which costs about $2.00 (U.S.)for the 120 feet length needed for the still. A better alternative is plastic covered galvanized steel wire which is used to make gabions for control of sea beach erosion. This is made by the Maccaferri Organization, Bologna, Italy, and is marketed in many countries by River and Sea Gabions (London) Ltd., England. They supply plastic covered galvanized steel wire, 15 metric gauge,0.0945 inches diameter, in rolls weighing 70 kg. (154 lbs.). The 120 feet length of wire needed for one still costs about $1.50 (U.S.) and one roll is enough for about 45 stills.

THE TRANSPARENT COVER

Select the transparent sheet compatible with the installation you have in mind, as outlined earlier. It is important to check the lifetime of the plastic under the severe conditions of exposure that prevail in this application. The plastic sheet will not last indefinitely, but the still design is such as to permit its replacement with relative ease, whenever necessary.

Plastic sheet is not normally wettable so, unless the underside is pretreated, the condensing water will tend to fall back into the brine rather than run down the film into the fresh water troughs at the edges.

This treatment is not very complex. It involves merely roughening the underside by carefully scratching with a very fine grit of wettable sandpaper. This treatment creates a network of very fine scratches on the surface, and is best carried out before construction of the still commences. The film should be wet sanded while being removed from its original roll, being transferred to a second roll in the process. Sand in one direction only - along the width of the plastic film.

The wet sanding need not be carried to the extreme outer edges of the plastic; a 4 inch to 6 inch strip on each edge should be left unsanded. It must be remembered that sanding will weaken the film. Hence it is recommended to use 0.010 inch thick film so that it can withstand stress. On the other hand, there are certain wetting agents that are reputed to cause filmwise condensation on plastic sheets. One of these is called Sun Clear and is manufactured by Solar Sunstill Inc., Setauket, New York 11733, U.S.A. One of the most difficult facets of this entire process is producing the wettable surface on the plastic film. If a wetting agent is used successfully, then there is no harm in using a thinner film such as 0.004 to 0.006 inches thick. For plastic current prices see materials list given at the back of this leaflet.

STEPS IN CONSTRUCTION OF STILL

(1) Choose a suitable site, preferably along the side of an existing fence that is on ground sloping gently towards the equator. Allow 6 ft. clearance to the fence. Remove all bushes and large stones, also smooth any gross irregularities. The site should not be shaded from 0800 hrs. to 1600 hrs.

(2) Dig two trenches for the foundation about 3 inches deep and 9 inches wide. The trenches should be 4 ft. apart. Dig similar trenches for the two end walls.

(3) Cast the concrete foundation (mix 8 : 4 : 1 stone: sand:cement). The top of the concrete must not be levelled into steps, as is usual when building walls, but must slope generally the same as the terrain and must be free of humps and dips. Ideally, the two concrete foundations, one along each side, should be perfectly parallel with each other.

(4) Remove all grass and 4 inches of soil from between the concrete footwalls. Replace with an equal volume of sand. Spray with a powerful grass killer and insecticide to prevent subsequent root growth under the still and insect damage to the plastic.

(5) Lay the 6 ft. lengths of galvanized steel guttering on the concrete footwall, pinning to the concrete with short nails, if necessary. This is best done on the day after the concrete footwall is laid. The guttering along the two footwalls should be exactly 4 ft. apart. It would be better, if available to utilize asbestos cement stripping. This, of course, would be far more difficult and costly to attach to the concrete footings, but it would not deteriorate which is unfortunately the case with the galvanized strip. Pieces of asbestos stripping could be used and attached onto the short vertical wall of the concrete foundation or, better still, cast directly into the footing.

(6) Lay the first row of bricks on the footwall, bedding firmly in mortar (mix 6 : 1). These bricks should rest partly on top of the

guttering, and should be 4 ft. 4 in. apart. The top of the bricks should slope towards the inside to facilitate drainage, the outer edge being about ¼ inch higher than the inner edge.

(7) Build a series of earth mounds across the space between the guttering, so as to make a series of dams to impound the water*. The mounds should be built almost up to the level of the top edge of the guttering, but with one low spot to create an overflow weir about ½ inch below the level of the top edge of the guttering. Level the sand in both directions between the footwalls and the earth mounds.

(8) Build the end walls, with the ridge point being about 16 inches above the footwall. In the end wall at the high end of the still, build into the wall a short length of ½ inch polyethylene hose-pipe, for the salt water feed. This pipe should be about 6 inches above the foundation. In the end wall, at the low end of the still, leave a 3 inch square opening opposite each of the two gutters, and another near the middle. These openings should be immediately above the concrete foundation so that, when the polyethylene liners are eventually laid, the overflow water can be guided through these openings.

(9) Lay the 18 in. wide black polyethylene plastic along each side wall, tucking it down into the guttering so as to form a waterproof liner to carry the distilled water down to the bottom drain holes. Fit plastic elbows and nipples with suitable nuts and washers to form watertight distillate and drain exits**. (See Fig. 1). Attach polyethylene tubing to carry distilled water to a storage reservoir.

(10) Starting at the low end of the still lay the 8 ft. wide black polyethylene liner, carefully folding it up and over the guttering on top of the first liner. This liner must be loosely laid. Water should be led into each dam as the liner is laid, to ensure that the entire width of the still is covered with water and that the earth mounds are adequate to impound the water.

(11) Cut sections of ½ inch rigid polyethylene tubing 1½ inches long; split the piece lengthwise on one side and clamp over the plastic liners covering the guttering strip. This should keep the liners in place.

(12) Place the stainless steel ridge-wire threaded through the polyethylene tubing (Item No. 18) in place with firm anchors at each end as shown in Fig. 2.

(13) Place the support props in position, being particularly careful not to puncture the plastic liner. These supports should be placed roughly every 8 to 10 feet so as to prevent any severe sagging of the gabion wire. It would be wise to attach the wire to the top of the A-frame prop. This could be fixed in place with some plastic sheeting. One suitable way of building these A-frames has been to make them of wood, treat them against rot in humid atmospheres, and then cover them with plastic sheets. This would at least extend their life somewhat. The pad resting in the distillate gutter should be firmly wedged against the brick wall. This pad should be encased in black polyethylene sheet so as to prevent its deterioration by the distillate water. The A-frame should be built as solidly as possible as this will be the basis of the support of the transparent cover. The angle of the A-frame with the horizontal should be between 15 and 20 degrees.

(14) In order to ensure that the condensed water droplets on the inside of the plastic sheet tent cover fall directly into the guttering,

*Build earth mounds every 10 to 12 feet.

** Fit plastic elbows, nipples etc. only after completing step 10.

cast a 1½ inch semi-circular cement lip (2 to 1 sand, cement mix) on the underside of the retaining bricks. (See Fig. 3). There should be at least 1 inch clearance between the base of the lip and the top of the guttering strip.

(15) Unroll the plastic sheet tent cover pinning it to the lower end wall with suitable straps. Open the entire length of plastic sheet using bricks temporarily placed on the side walls to keep it in position. Be sure that the roughened surface of the plastic sheet is on the underside. When the plastic sheet is correctly positioned it can be firmly fixed along both edges by two work crews working opposite each other, starting from the lower end. This is done by stretching the plastic sideways and pinning into the mortar between the bricks of the lower brick layer, using large-head 1 inch galvanized nails. The top weighting bricks should be placed in position before the pinning nails are driven in. If the weighting bricks are very rough, they are likely to cut the plastic sheet unless lined. The 15 inch wide roll of black polyethylene plastic must be used for lining the top bricks. A second layer of weighting bricks might have to be placed on top of the first layer, to be sure that the wind will not cause the flapping plastic sheet tent to work loose.

While the plastic sheet is being installed, it is advisable to keep the still filled with water in order to prevent overheating of the inner liner.

Finally the plastic sheet tent should be stretched and fixed to the outer edge of the footwalls with aluminum strips secured by screws.

(16) Rain water should be allowed to drain off the tent at intervals along the length of the unit, so as not to cause the plastic to sag in heavy rain storms. This is best done by leaving a spacing of a few inches between each adjacent block at the lower end of the still.

(17) Storm water should be kept away from the still because moisture in the soil beneath the tray will greatly increase the loss of heat through the bottom.

(18) The still area should be fenced to keep animals out. Since excess wind can reduce the output of water, low windbreaks, such as uncut grass one or two feet high around the still should be encouraged.

OPERATION OF THE STILL

Other than to ensure a regular supply of water to the tray, the still requires no attention. If sea water is being used, it is important that the concentrated brine be flushed out daily, so as to prevent salt deposition in the tray. The flushing operation is best started at dawn, and should last only about one hour. It is sufficient to add twice as much makeup water each day, as is produced as fresh water, allowing the excess to drain away from the lower end of the still. Alternatively, if the still is to operate without daily attention for flushing, the excess salts can be flushed away by providing a slow steady feed of the salt water all day and night. The feed rate should be adjusted so that the overflow from the bottom end will just cease in the middle of the afternoon when evaporation is greatest. A steady glow of 2 to 3 gallons per hour would

be suitable for this 100 ft. long still. It may be necessary to add small quantities of acid to the still to prevent the formation of scale within the basin. In this case, keeping the pH of the still about 6 should prevent all possibility of scale formation.

DISTILLED WATER FOR CAR BATTERIES

Distilled water for car batteries usually costs about 10 U.S. cents per gallon. Since solar stills produce distilled water for about one tenth of this cost, small solar stills should find wide use on farms and at service stations (garages).

TOTAL COST OF THE STILL

Representative figures for the cost of the materials for the still are given in the last column of the Materials List. The total cost of materials is the local currency equivalent of about U.S. $228. The cost of the labour to construct the still will vary widely with location, but will probably be of the same order as the materials cost. The completed still of 400 square feet active area will therefore cost about U.S. $450. equivalent, that is at a rate of U.S. $1.10 per square foot. Of the total cost, only one quarter part, that is the U.S. $100. to pay for Items 1 to 6, may require foreign exchange. Many of the other items may be improvised using suitable substitutes of locally available materials. This still has therefore potential application in many countries. The capital cost is about U.S.$11. per imperial gallon per day output, which is competitive with other small distillation plants. The solar still, however, has the great advantage that at least three quarters of its cost is composed of local labour and materials, whereas mechanical distillation plants have to be imported from abroad. Even on a strict economic basis the still should pay for itself within a period of five years.

NOTE

It is recommended that persons intending to build these units make use of this brochure as a guide only. It is essential that they adhere to the principle of the operation involved. However, they must show as much flexibility as possible in actually effecting any installations as to the adaptation and use of locally available materials. The application of this plastic covered still would be best for temporary, semi-permanent installations, due to the very nature of the materials involved which occasionally need renewing. If indeed a permanent installation is required then a glass-covered still would be recommended. In this case please contact this Institute and order the following publications:

(see following page)

ADDITIONAL LEAFLETS AVAILABLE FROM THE BRACE RESEARCH INSTITUTE ON SOLAR DISTILLATION

T.17 Simple Solar Still for the Production of Distilled Water, by T.A. Lawand, 6 p., September 1967. Price - $0.75

T.58 Plans for a Glass and Concrete Solar Still, by T.A. Lawand and R. Alward, 9 p., December 1968. Price - $3.00

I.66 Some Notes on the Construction Cost of Auxiliaries for the Haiti Solar Still, by R. Alward, 10 p., March 1970. Price - $0.50

I.67 Installation of a Solar Distillation Plant on Ile de la Gonave, Haiti, by R. Alward, May 1970. Price - $0.50

PRICE RANGE OF DIFFERENT THICKNESSES OF PLASTIC FILM

Approximate Prices $U.S. per square foot

Film	Thickness of Film		
	0.004" (4 mil)	0.006" (6 mil)	0.010" (10 mil)
Ultra-violet resistant, transparent polyethylene	0.015	0.020	0.025
Ultra-violet resistant, transparent polyvinyl chloride	0.045	0.070	0.115

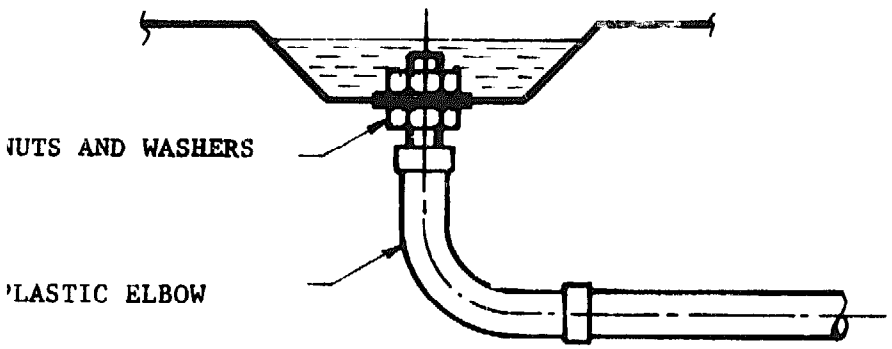
MATERIALS LIST FOR 400 SQ. FT. STILL

ITEM	DESCRIPTION	MATERIAL	DIMENSIONS	QUANTITY	PRICE
1	Transparent plastic roof	ultra-violet resistant polyvinyl chloride film	0.010 in. thick, 6ft. x 100 ft.	one piece	66.00
2	Plastic salt pond liner	black polyethylene film	0.010 in. thick, 10 ft. x 100 ft.	one piece	15.00
3	Plastic trough (lower) liner	black polyethylene film	0.010 in. thick, 18 in. x 100 ft.	two pieces	3.60
4	Plastic side wall (upper) liner	black polyethylene film	0.010 in. thick, 15 in. x 100 ft.	two pieces	3.75
5	Brine inlet and fresh water outlet pipes	polyethylene hosepipe, clips and fittings	½ in. dia. x 14 ft. long, stainless steel clips, plastic elbows, nuts and washers	nineteen pieces	7.00
6	Roof suspension wire	stainless steel wire, 1000 lb. breaking strength or gabion wire	120 ft. long	one piece	2.00
7	Cable turnbuckles	galvanized steel	¼ in. x 4 in.	two pieces	4.00
8	Anchor posts	steel fence posts	4 ft. long	six pieces	9.00
9	Nails to pin guttering	galvanized steel (clouts)	1 in. long, large flat head	500 pieces	.50
10	Steel guttering	galvanized steel	26 gauge, 3 in. x 3 in. right angle, 6 ft. long	40 pieces	21.20
11	Wall bricks	concrete blocks	4 in. x 8 in. x 16 in.	150 pieces	18.00
12	Cement	foundations	94 lb. bags	6 bags	8.30
13	Sand	foundations and basin sand		6 cu. yds.	16.00
14	Stone	graded local stone		2 cu. yds.	7.00

Table continued

ITEM	DESCRIPTION	MATERIAL	DIMENSIONS	QUANTITY	PRICE
15	flat white paint			1 pint	1.70
16	A-frame prop to hold up wire	wood or other suitable material	1½ in. x 1½ in. x 28 ¾ in.	22 pieces	6.00
	A-frame (brace)		1½ x 1½ x 16 in.	11 pieces	
	A-frame foot pad		½ in. x 2½ in. x 9 in.	22 pieces	
17	plastic sheet needed for covering for A-frames	polyethylene	0.010 in. thick	20 sq. ft.	0.30
18	Tubing for wire	polyethylene	3/16 in. I.D., 5/16 in. O.D.	100 ft.	8.00
19	Weedkiller	Gramevin-Fenac Type	sufficient for multiple applications		8.30
20	Sandpaper	No. 180-C-W 661J	11 in. long x 9 in. wide	14 sheets	1.80
21	Transparent roof attachment	aluminium strips	1/16 in. x 3/4 in. x 6 ft.	36 pieces	16.00
22	Screws		No. 7 - 1 in. aluminum	1 gross	2.00
23	Guttering attachments	plastic hose clips	1½ in. long - ½ in. dia., rigid plastic hose	60 pieces	1.00
24	End doors	plywood	½ in. thick, 4 ft.	3 pieces	2.00
				TOTAL U.S. $	228.45

It must be appreciated that this price list has been prepared using locally available costs in the West Indies. Basically however, these prices should not differ substantially from those encountered elsewhere. It should therefore only be used as a guide.



DRAIN AND DISTILLATE CONNECTIONS

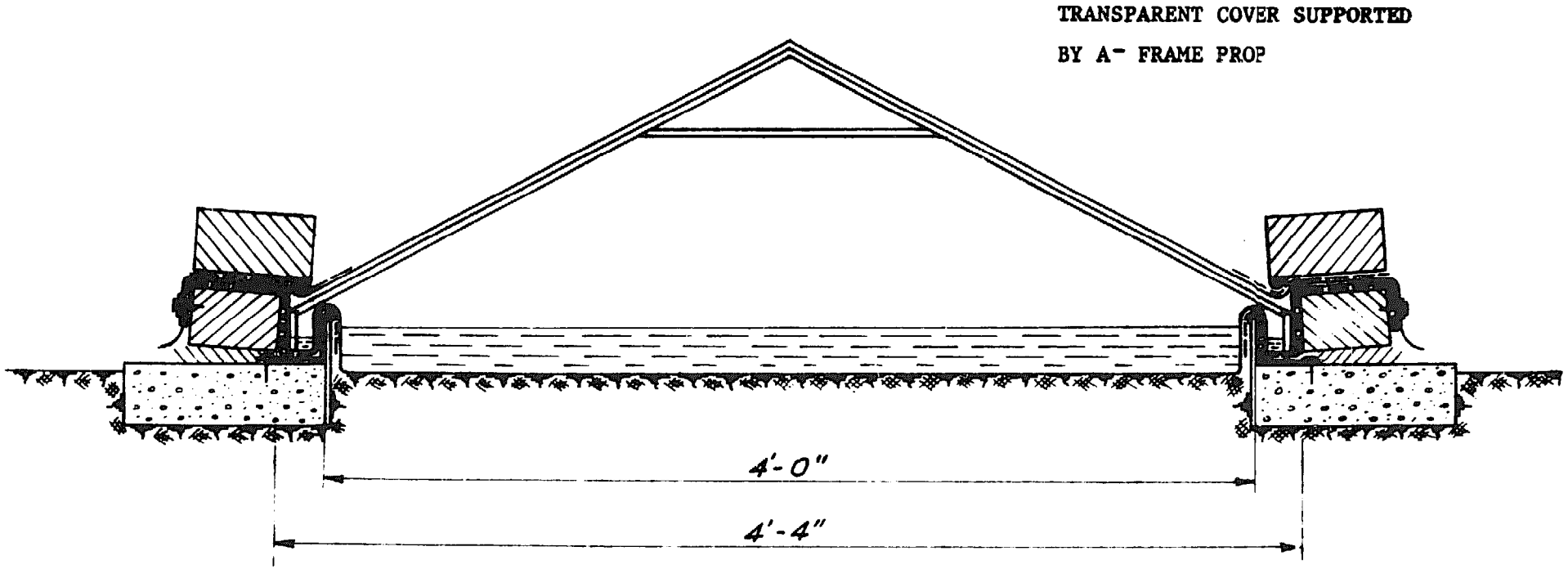


FIG No 1 - CROSS SECTION OF THE SOLAR STILL

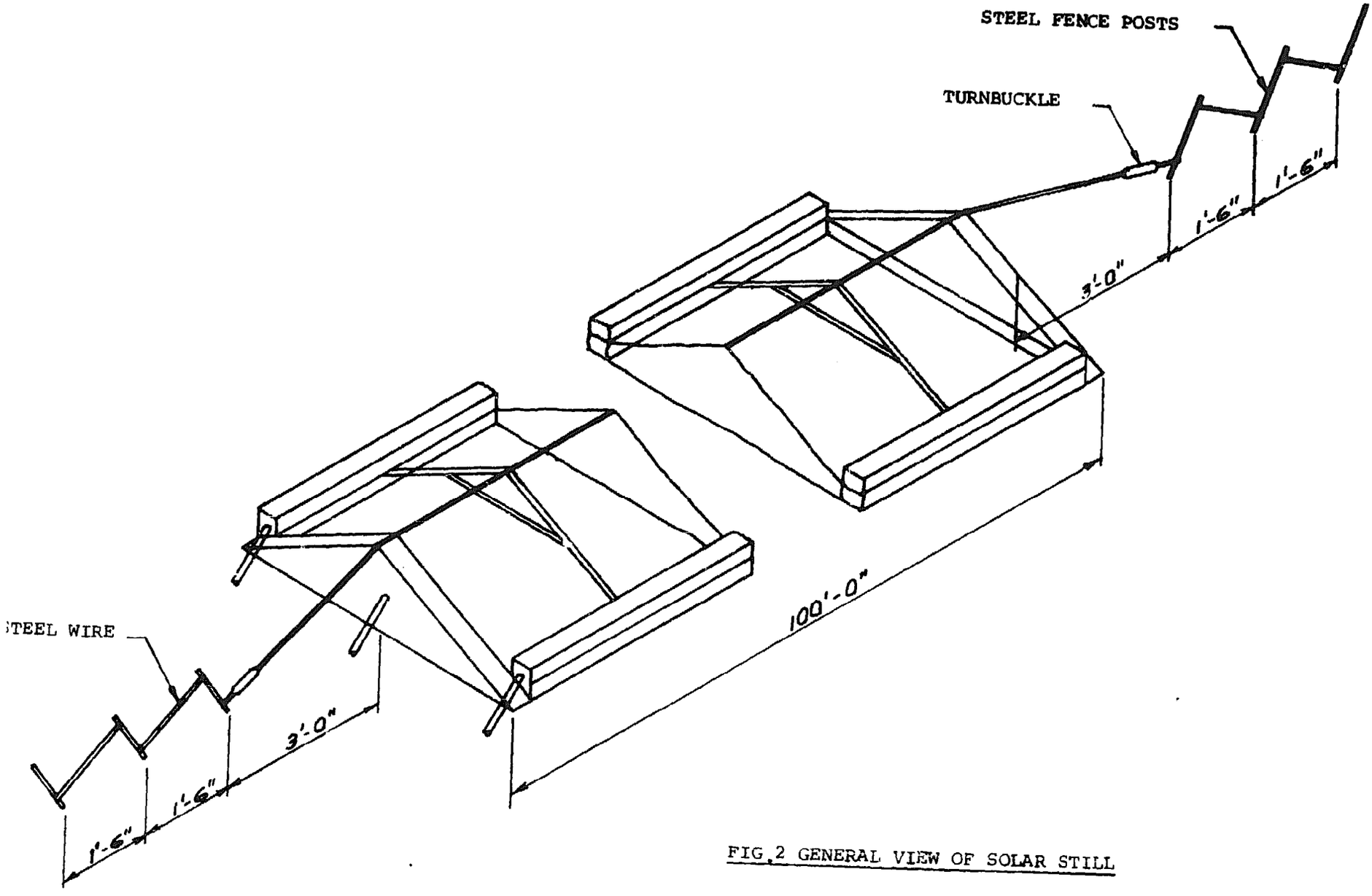


FIG.2 GENERAL VIEW OF SOLAR STILL

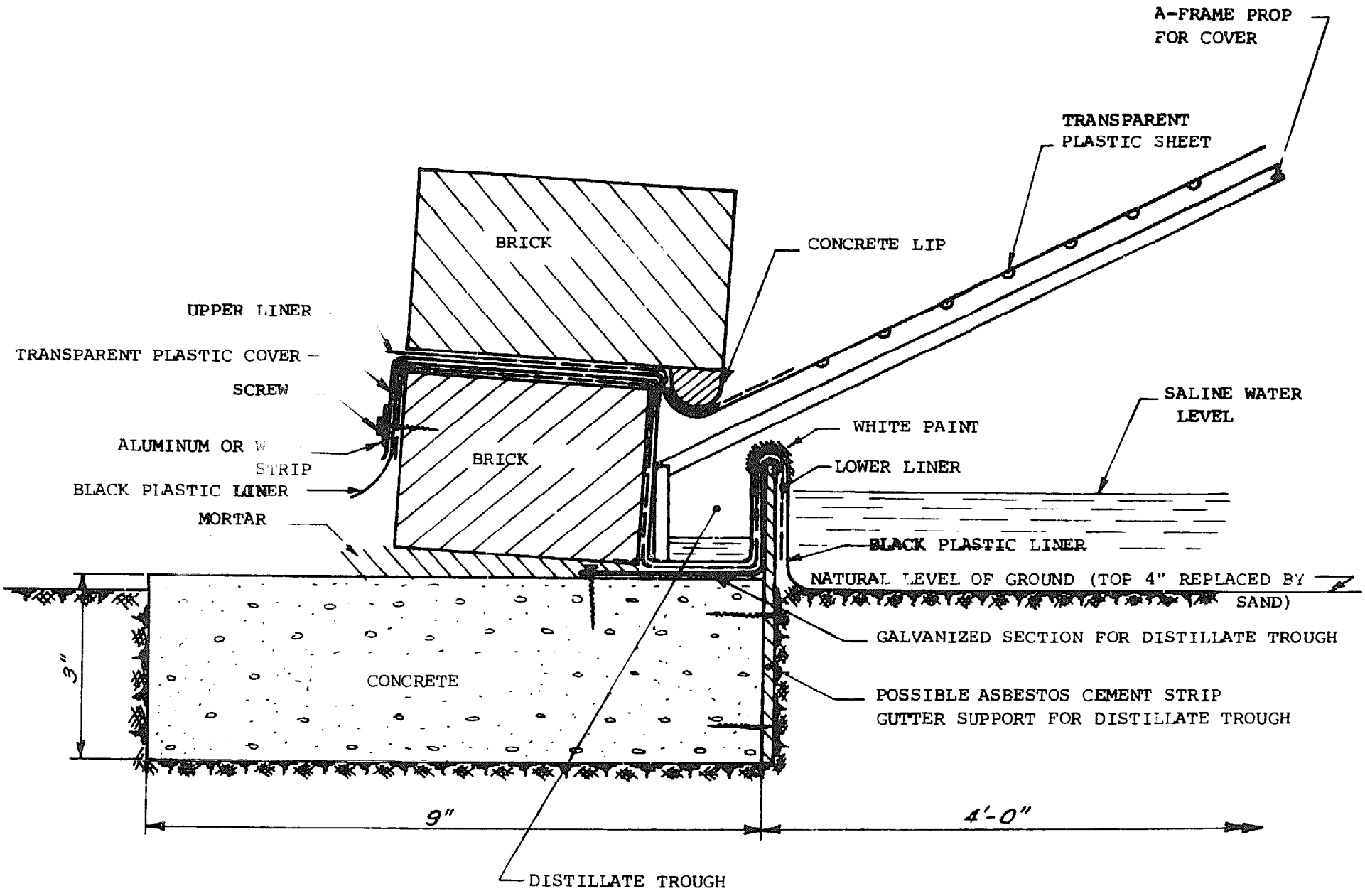


FIG No. 3 - CROSS SECTION OF SIDE WALL OF SOLAR STILL

Background Information on the Brace Research Institute

Brace Research Institute of McGill University was founded in 1959 to develop equipment and techniques for making dry lands available and economically useful for agricultural purposes. The Institute has concentrated on the problems affecting individuals or small communities in rural areas and is one of the few organizations with this basic objective.

In general, equipment developed by this Institute utilizes as many local resources as possible, whether human, energy or material, so that the technology can be easily adapted to the local environment. As a result, the Institute has concentrated on utilizing solar and wind energy as well as simple desalination systems, specifically concentrating on the problems that face isolated rural populations in developing arid areas.

Instructional manuals are available describing the use of solar energy for the

(1) heating of water for domestic and commercial use
(2) cooking of food
(3) drying of agricultural produce
(4) desalination of water for human, animal and agricultural use

The adaptation of simple greenhouses combined with solar desalination systems for the production of food and water in arid areas is also being developed. Greenhouses are also being adapted for colder regions.
In addition, simple windmills for the production of electricity and the pumping of water have been developed.

Further inquiries should be directed to the

Brace Research Institute,
Macdonald College of McGill University,
Ste. Anne de Bellevue H9X 3M1,
Québec, Canada

Other leaflets available:	Price
L1 - How to Make a Solar Still (plastic covered)	$1.25
L2 - How to Make a Solar Steam Cooker	$1.25
L3 - How to Heat your Swimming Pool using Solar Energy	$0.75
L4 - How to Build a Solar Water Heater	$1.25
L5 - How to Construct a Cheap Wind Machine for Pumping Water	$1.25
L5F- French version of L5	$0.75
L6 - How to Make a Solar Cabinet Dryer for Agricultural Produce	$1.25
L7 - Arabic Translation of L6	$1.25
L8 - Spanish Translation of L6	$1.25
L9 - French Translation of L2	$1.25
T17- Simple Solar Still for the Production of Distilled Water*	$1.25

Please remit payment with money order or add $0.25 to your cheque for bank handling charges.
* Also available in French, Arabic and Spanish.